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Accuracy and agreement of automated oscillometric blood pressure measurement compared with manual auscultation

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Abstract

Background: Accurate blood pressure (BP) measurement is essential for the diagnosis and management of hypertension. Automated oscillometric BP monitors are increasingly used in clinical settings; however, discrepancies compared with manual auscultatory measurements may occur due to device- and technique-related factors. **Objectives:** To compare automated digital BP readings with manual sphygmomanometer measurements and to assess the impact of arm circumference and arm position on measurement differences.

Methods: This prospective method-comparison study was conducted at Pramukhswami Medical College, Gujarat, from May to July 2025. Adult participants underwent BP measurement using both a validated automated BP monitor and a manual mercury sphygmomanometer in the same arm. Two readings were obtained with each method, and mean values were analyzed. Mean differences, proportions of readings differing by >10 mmHg, and the effects of arm circumference and arm position were evaluated.

Results: Automated BP readings showed significantly higher mean systolic and diastolic values compared with manual measurements. Twenty percent of systolic and 15% of diastolic readings differed by more than 10 mmHg. Larger arm circumference and incorrect arm positioning were significantly associated with greater BP discrepancies.

Conclusion: Automated BP monitors are convenient but require proper validation, correct cuff sizing, and standardized technique to ensure accurate clinical use.

Key words: Blood pressure measurement, Automated blood pressure monitor, Sphygmomanometer, Cuff size, Arm position

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Introduction

Accurate blood pressure (BP) measurement is fundamental for diagnosing and managing hypertension, yet routine clinic practice increasingly relies on automated oscillometric BP monitors whose readings may differ from manual auscultatory sphygmomanometry due to device algorithms, technique, and patient-related factors [1]. Even small systematic differences can shift patients across treatment thresholds, influencing labeling, medication initiation, and follow-up intensity [1]. Recent evidence shows that "miscuffing" (using an incorrect cuff size) can produce clinically meaningful errors with automated devices, with larger-arm individuals particularly vulnerable to overestimation when a standard cuff is used [2]. In addition, the growing diversity of home and clinic devices highlights the importance of validation against accepted standards and real-world performance checks, because not all commercially available monitors meet accuracy requirements [3]. In this context, a pragmatic prospective method-comparison study in a routine outpatient setting can quantify agreement between a digital BP monitor and a manual sphygmomanometer, estimate the mean systolic/diastolic differences, and determine the proportion of paired readings that differ by more than 10 mmHg [2]. The aim of the study is to compare automated (digital) BP measurements with manual auscultatory BP readings in adults and to evaluate whether arm circumference (cuff fit) and arm position influence measurement discrepancies.

Methods

This prospective method-comparison study was conducted at Pramukhswami Medical College, Gujarat, over a three-month period from May to July 2025. Adult patients attending the outpatient department and general wards were consecutively enrolled after obtaining written informed consent. The study was approved by the Institutional Ethics Committee, and all procedures were performed in accordance with the principles of the Declaration of Helsinki. Adults aged 18 years and above who were willing to participate and could maintain a seated position for BP measurement were included. Patients with cardiac arrhythmias (such as atrial fibrillation), upper-limb deformities, arteriovenous fistula, lymphedema, or conditions precluding accurate BP measurement were excluded. The study design was observational and prospective, aiming to compare automated (digital) BP readings with manual auscultatory measurements obtained during the same visit.

BP measurements were performed using a validated automated oscillometric BP monitor and a calibrated mercury sphygmomanometer with a standard stethoscope. Participants were instructed to avoid caffeine, smoking, and physical exertion for at least 30 minutes prior to measurement. After a rest period of five minutes, BP was measured in the sitting position with the back supported, feet flat on the floor, and the arm supported at heart level. Arm circumference was measured at the midpoint between the acromion and olecranon, and an appropriately sized cuff was selected according to manufacturer recommendations. In each participant, BP was measured in the same arm using both methods, with the order of measurement alternated between participants to minimize order bias. Two readings were obtained with each device at an interval of two minutes, and the average of the two readings was considered for analysis. Systolic BP (SBP) and diastolic BP (DBP) values were recorded separately for the digital and manual methods.

In addition to BP values, demographic and clinical variables including age, gender, body mass index, arm circumference, and arm position during measurement were recorded in a predesigned case record form. Arm position was categorized as correct (arm supported at heart level) or incorrect (arm unsupported or positioned below/above heart level) based on direct observation at the time of measurement. The primary outcome measures were the mean difference between automated and manual SBP and DBP readings and the proportion of paired readings showing a difference greater than 10 mmHg. Secondary outcomes included assessment of the effect of arm circumference and arm position on BP discrepancies. All data were entered into Microsoft Excel and subsequently analyzed using SPSS version 20. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. Agreement between the two methods was evaluated using mean differences and limits of agreement, and subgroup analyses were planned to explore factors influencing measurement differences.

Results:

The study demonstrated that automated digital BP monitors yielded slightly higher systolic and diastolic readings compared to manual sphygmomanometer measurements. The mean SBP difference was +2.8 mmHg, while the mean DBP difference was +1.5 mmHg, indicating a small but consistent overestimation by the automated device (Table 1). Although most paired readings were within an acceptable range, one-fifth of systolic measurements and 15% of diastolic measurements differed by more than 10 mmHg, which may be clinically significant for hypertension diagnosis and management (Table 2). Analysis of contributory factors revealed that larger arm circumference (≥30 cm) was associated with greater systolic BP discrepancies compared to smaller arms, highlighting the impact of cuff fit on measurement accuracy. Similarly, incorrect arm positioning resulted in substantially higher BP differences than measurements taken with the arm supported at heart level (Table 3). These findings emphasize that while automated BP monitors are convenient and suitable for routine use, proper technique including correct cuff size and arm positioning—is essential to minimize measurement errors. Overall, the results support cautious interpretation of automated BP readings, particularly in individuals with larger arm circumference or suboptimal measurement posture.

Discussion:

Automated oscillometric BP monitors are increasingly used in outpatient clinics because they reduce observer bias (terminal digit preference, rapid deflation, and inter-observer variability) and allow standardized repeated readings, but their accuracy depends on device validation and strict adherence to technique [4]. Contemporary guidance emphasizes that clinic BP should be obtained with the patient seated quietly, back supported, feet flat, no talking, and with an appropriately sized cuff and the mid-cuff at heart level, because departures from these steps can shift BP enough to alter diagnosis and treatment decisions [4, 5]. In our prospective method-comparison study, the digital monitor produced slightly higher mean SBP/DBP than manual auscultation, and although the average bias was small, a meaningful proportion of paired readings differed by >10 mmHg, indicating that acceptable average agreement can still hide clinically important individual-level disagreement [1]. This pattern aligns with the broader evidence that oscillometric devices estimate SBP/DBP using proprietary algorithms derived from the oscillation envelope, and therefore they may diverge from auscultatory values depending on arterial stiffness, pulse pressure, and measurement conditions [1].

A key implication of our results is that measurement conditions, not merely "device type," likely explained much of the large-difference outliers. Device validation standards (e.g., ISO 81060-2) exist because unvalidated monitors may have greater bias and variability, increasing the risk of misclassification when used at scale [6]. Unfortunately, marketplace analyses suggest that a large proportion of devices sold globally have no publicly available evidence of clinical validation, which creates a hidden quality problem when clinics or patients purchase monitors based on cost or convenience rather than validation status [7]. Practical reviews now recommend that clinicians and institutions use validated-device registries and procurement policies that restrict purchase to devices that have passed recognized protocols [8]. Our findings support that recommendation: even when a

monitor is generally reliable, using an unvalidated model (or one outside its validated cuff range) could plausibly amplify disagreement beyond what we observed, particularly in busy outpatient settings where technique is variable [6 – 8].

The strongest explanatory signal in our dataset was the association of larger arm circumference with greater systolic discrepancy, reinforcing that cuff fit is not a minor detail. A randomized crossover trial quantified the impact of miscuffing on automated BP and showed that using a regular cuff when a different size was required produced clinically meaningful errors, especially for participants needing large or extra-large cuffs, where SBP could be substantially overestimated [9]. A linked commentary emphasized the public health consequence: systematic miscuffing can create overdiagnosis and overtreatment in people with larger arms, while the opposite can occur in those needing smaller cuffs [10]. Our observation of higher SBP differences in larger arm circumferences is consistent with this mechanism and highlights an actionable fix routine mid-arm circumference measurement and ready access to multiple cuff sizes rather than assuming a single "standard cuff" is acceptable for most adults [9, 10].

Arm position also emerged as a major source of discrepancy, with incorrect positioning showing markedly higher SBP differences. This is biologically plausible because hydrostatic effects and isometric muscle activity can elevate measured BP when the arm is unsupported or below heart level. A recent randomized crossover clinical trial demonstrated that common nonstandard arm positions (arm in lap or hanging at side) substantially overestimate BP, enough to increase the likelihood of misdiagnosis of hypertension [11]. Our findings mirror this real-world problem: even with correct cuff size, poor arm support/height can inflate automated readings and widen disagreement with manual measurements, particularly when the manual reading is taken more carefully by a trained observer [11]. For clinical practice, this means that training and workflow design (chair + table height, arm support, visual reminders) may yield larger accuracy gains than switching devices, because both manual and automated methods are vulnerable to posture and positioning errors [4, 11].

Finally, our results should be interpreted within the evolving shift toward automated office BP (AOBP) protocols that use multiple unattended readings to reduce white-coat effects and improve reproducibility. Evidence indicates that when AOBP is performed correctly quiet setting, minimal interaction, repeated measures it aligns more closely with ambulatory BP and can be preferable to routine single manual readings [12]. At the same time, feasibility in busy clinics has driven research on streamlined protocols, including the impact of rest duration before measurement; trials such as Best Rest and "Zero to Five" explored whether shorter rest periods meaningfully change AOBP compared with longer guideline-recommended rest, informing pragmatic implementation without sacrificing accuracy for most patients [13, 14]. Newer studies also suggest that waiting-room AOBP may be a workable alternative when dedicated rooms are unavailable, potentially improving adoption while preserving diagnostic performance [15]. Taken together, our study supports a practical conclusion: automated devices can be used confidently only when (i) the device is validated, (ii) cuff sizing is individualized, and (iii) positioning/rest protocols are standardized; otherwise, a substantial minority of patients may have differences large enough (>10 mmHg) to affect clinical decisions, warranting repeat measurement and confirmation.

Conclusion: This prospective method-comparison study demonstrated that automated digital blood pressure monitors tend to yield slightly higher systolic and diastolic readings compared with manual auscultatory measurements. Although the mean differences were small, a clinically significant proportion of readings differed by more than 10 mmHg, which could influence hypertension diagnosis and management. Larger arm circumference and incorrect arm positioning were important contributors to measurement discrepancies. These findings highlight that automated BP monitors can be reliably used in routine clinical practice only when validated devices are employed and strict adherence to correct cuff sizing and standardized measurement technique is ensured.

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Table 1: Comparison of manual and automated BP measurements among the study members

Parameter	Manual BP	Digital BP	P value
SBP	128.4 ± 16.5	131.2 ± 17.1	0.002
DBP	82.6 ± 9.8	84.1 ± 10.2	0.018

Table 2: Proportion of readings with >10 mmHg difference between methods

Parameter	Difference n (%)		P value
	≤10 mmHg	>10 mmHg	
SBP	96 (80.0)	24 (20.0)	0.011
DBP	102 (85.0)	18 (15.0)	0.039

Table 3: Effect of arm circumference and arm position on SBP discrepancy

Variable	Mean SBP difference	P value
Arm circumference <30 cm	1.6	0.004
Arm circumference ≥30 cm	4.3	
Correct arm position	1.9	<0.001
Incorrect arm position	5.1	